THE DEVELOPMENT OF SOLAR IRRADIATION LEVELLING SYSTEM USING COLOUR CONTOUR APPROACH

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For my beloved father and mother,

Abd.Hadi Bin Mohammad &Rahimah Binti Mamat

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ABSTRACT

This project presents the development of solar irradiance levelling spectrum using colour contour approach. The system developed by using the General User Interface (GUI) Matlab. The advantage of the system is irradiation data being easily analysed by the user. Furthermore, the system reduces the time taken to calculate the energy of each level and the total energy of solar irradiation. The irradiance levelling is using three specific colour ranges according to three level of the system. The result from the GUI Matlab shows the data being levels into maximum, medium and minimum level. The specific colours uses are red, yellow and green. Microsoft Excel was used to prove the calculation of energy and total energy and the comparison of the graph in GUI.

ABSTRAK

Projek ini membentangkan pembangunan pengasingan spektrum sinaran matahari melalui pendekatan kontur warna. Sistem ini dibangunkan dengan menggunakan Antara Muka Pengguna Umum (GUI) Matlab. Antara kelebihan sistem ini ialah data penyinaran mudah dianalisis oleh pengguna. Tambahan pula, sistem dapat mengurangkan masa yang diambil untuk mengira tenaga bagi setiap peringkat dan jumlah keseluruhan tenaga sinaran matahari.Sinaran ini diasingkan menggunakan tiga warna tertentu mengikut tiga tahap sistem. Hasil dari Matlab GUI menunjukkan data di bahagikan kepada tahap maksimum, medium dan tahap minimum dengan menggunakan warna merah, kuning dan hijau. Microsoft Excel digunakan untuk membuktikan pengiraan tenaga dan jumlah tenaga serta perbandingan graf dalam GUI.

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LIST OF ABBREAVIATIONS AND SYMBOLS

ANN	-	Artificial Neural Network
CWT	-	Continuous Wavelet Transform
EMD	-	Empirical Mode Decomposition
ERBS	-	Earth Radiation Budget Satellite
GUI	-	Graphical User Interface
HHT	-	Hilbert Huang Transform
IMF	-	Intrinsic Mode Function
LOG	-	Logging
MAPE	-	Mean Average Percentage Value
MAX	-	maximum
MIN	-	minima
PV	-	Photovoltaic
SDL	-	Solar Data Logger
WTMM	-	Wavelet Transform Modulus Maxima
XFER	-	Transfer
S		Solar constant
E		Sun total power
R		Average earth/sun distanced

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CHAPTER 1

INTRODUCTION

1.1 Project background

Irradiation is the measure of energy density of sunlight and is measured in kWh/m^2 and is the integral of irradiance since the energy is integrated over time. It is often expressed as peak sun hours (psh). The psh is simply the length of time in hours at an irradiance level of $1(kW/m^2)$ needed to produce the daily irradiation obtain from the integration of irradiance over all daylight hours. The irradiation data is important to estimate how much solar energy is available. Most important, solar energy technologies rely on it to provide energy and being use for modelling and design related device or system like photovoltaic (PV) system [1-4].

Spectrum analysis is amongst the most useful techniques in modern science use in many disciplines like astronomy, geology, medicine and solar system [5]. The modeling of the clear sky irradiance components of solar radiation is necessary in many applications of solar energy like systems design and simulation, control process of the accuracy of radiometers, data quality control, gaps filling process, as well as in routine engineering practice like the peak cooling load of buildings is determined for a hot, cloudless, summer day.

Furthermore, the effects of the cloud generally induce most of the variability and uncertainty in radiation calculations, years of hourly data are necessary to constitute a valid reference data set whenever a general assessment covering all types of sky conditions is needed.

1.2 Problem statements

Irradiation solar spectrum is a method to recognize the pattern of the solar irradiation throughout the day. The instruments will calibrated to measure the spectral irradiance in units of watts per meter squared over the wavelength range in nanometres. This has helped a lot of the researcher to monitor the irradiation level.

However due to so many data of irradiance in a day, the specific analysis of the irradiance pattern is time consuming [6]. As an example, when using Solar Data Logger (SDL) template the user need to upload the data from one application to another template in Excel before get the pattern. Furthermore, in order to obtain energy at certain level, manually calculation is needed. It leads an increase of the time taken to analysed. Moreover, problem may occur on how to read the irradiance level on the system due to the same colour for all data. Therefore, for the better understanding of the irradiation pattern, a method of solar irradiance levelling using colour contour approach will be developed.

1.3 Project objectives

The major objective of this research is to design a solar irradiation levelling spectrum that can easily be analysed by the user. Its measurable objectives are as follows:

(i) To determine the irradiance pattern through the specific colour spectrum.

(ii) To reduce the time taken by the user to measure the irradiation energy.

1.4 Project scope

This project is primarily concerned of irradiance implementation using Matlab- GUI. The scopes of this project are:

(i) The irradiation data of the solar system will be taken from 8 am until 6 pm.

(ii) The system depends on the three colour level according to the three irradiance level.

(iii) Matlab software will be used to develop and implement the data.

1.5 Report outlines

Chapter 1 gives a brief introduction of solar irradiation. It personalised explained about the problem statement which is the main reason of this solar irradiance levelling system project done. The objectives of the project together with the scopes are also being explained in this chapter.

Chapter 2 is the literature review, which contains the previous study that has some contribution to this project. Furthermore, there are methods that will be used in the project explained. There is explanation about equations that will be used, which is first for the plotting the colour levelling and second to calculate the energy.

The methodology part in Chapter 3, is about the method use in detail included with the flow chart to obtain each of the objective specify. The Chapter 4 is the important part of the project cause contains the result and analysis of the data from the Chapter 3. In the Chapter 5 is about the conclusion and recommendations.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A literature review is a critical compilation of previous research that outlines established findings, current knowledge and methods used. In this chapter, there will be an explanation of irradiation parameters and previous researches related to this project.

In section 2.2, reviews the previous study that has been done by other researchers. In this section contains two sub section, first section are issues related to solar irradiation analysis method and second section is about solar irradiation modelling using several method.

In section 2.3, contains the introduction about the solar irradiance in this project. In section 2.4, explain the basic of general user interface (GUI). Section 2.5 reviews the colour levelling. Lastly section 2.6 and 2.7 contains the explanations about the formula and the solar data logger (SDL).

2.2 Previous study

There are a few research works had been carried out related to this project to gain knowledge and further understand about the method, application of technology and solution of the problem. This review is made referring to the previous work study, present thesis related and paper which discuss topics about solar spectrum.

2.2.1 Issues that related to solar irradiation analysis

Hilbert Huang Transform (HHT) is a new method of analysing non-stationary and non-linear time series data [7]. Based on realization of HHT method in MATLAB software, they find that analytical capacity of HHT to time series in time-frequency domains stands out.

The results show that solar irradiance is completely decomposed into four Intrinsic Mode Function (IMF) components and an increasing trend by Empirical Mode Decomposition (EMD) method. Figure 2.1, shows the Hilbert Spectrum of Solar Irradiance.

The result of the paper uses the colour spectrum to plot the levelling of its normalised frequency versus time. The plotting in this paper does not show a big impact to the user. In this paper colour range cannot emphasize the differences of each level due to its almost similar colour before or after each range. However, the idea to levelling the data using the colour still can be used.

Whilst another paper has investigating multifractality of solar irradiance data through wavelet based multifractal spectral analysis [8]. In this paper they have tried to detect the irregularity and multifractality in the signal using continuous Wavelet Transform Modulus Maxima (WTMM) algorithm. The data obtained by Earth Radiation Budget Satellite (ERBS).

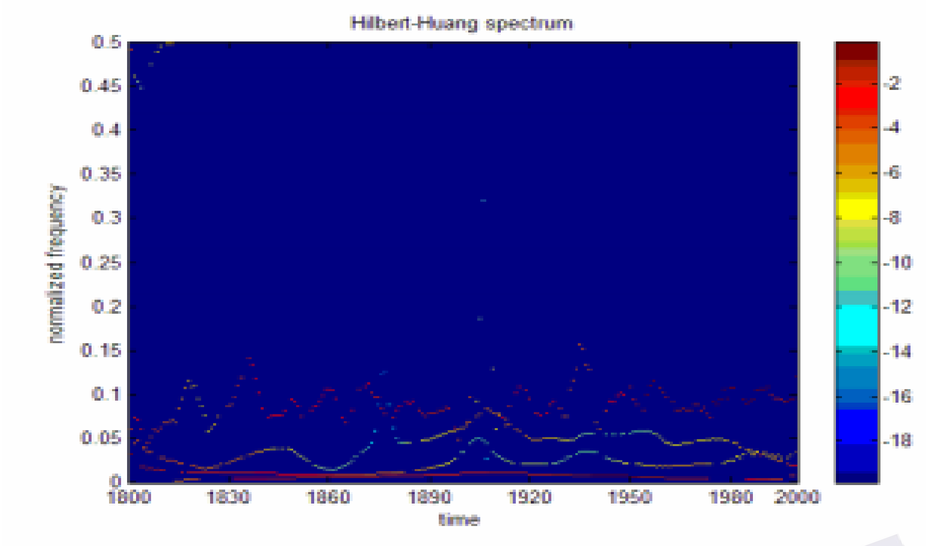

Figure 2.1: Hilbert spectrum of solar irradiance.

The scale colour from the MIN to MAX of the colour coded Continuous Wavelet Transform(CWT) coefficient have use 128 colour from the deep brown to white. This kind of plotting used the colour coding to plot the data. However, the colour look similar which is seemed varies from the dense to dim ones. The plot was obtained by using the Wavelet Toolbox of Matlab Software which is shown in Figure 2.2.

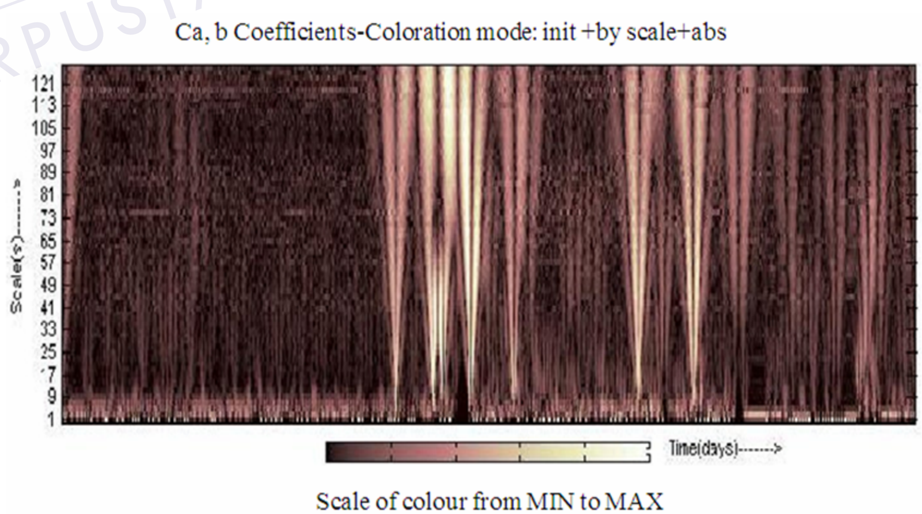

Figure 2.2: Colour coded CWT coefficient plot (Scale Vs. Time)

2.2.2 Issues of solar irradiation modelling

A research about the potential of wind and solar energy in Malaysia East Coast have been done to monitoring solar radiation and solar energy over a year period [9]. It has been carrying out measuring solar energy potential and the use of solar energy in Pekan. The measurement equipment has been installed to the tallest building in Universiti Malaysia Pahang. The result of the solar Irradiation data is in the Figure 2.3.

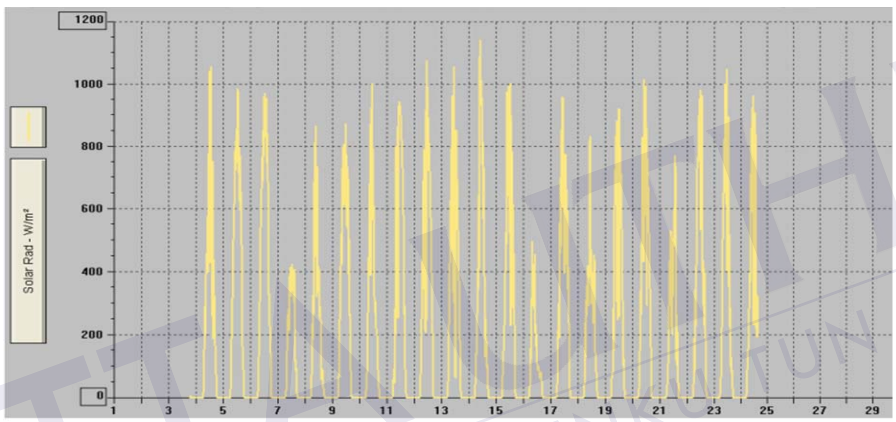

Figure 2.3: Solar radiation on month of June

The result in Figure 2.3, shown the solar radiation throughout the month of June, which is the data taken every day. They only use one colour to indicate the radiation pattern which is not very clear and hardly to be analysed. However, this research data is still in preliminary stage.

Another paper presents a solar energy prediction method using Artificial Neural Networks (ANNs) [10]. In order to calculate global solar irradiation an ANN used to predict a clearness index. The ANN model is based on the feed forward multilayer perception model with four inputs and one output.

The inputs are latitude, longitude, day number and sunshine ratio while the output is the clearness index.The main objective of this research is divided into two sub objectives: develop a feed forward ANN model to predict the clearness index based on the number of sunshine hours, day number and location coordinates and calculate the global solar irradiation based on the developed formulas for Malaysia. This work has been based on long term data for solar irradiations (1984-2004) taken from the 28 sites in Malaysia.Based on the results, the average mean value percentage error (MAPE), mean bias error and root mean square error for the predicted global solar irradiation are 5.92%, 1.46% and 7.96%. In this prediction does not provide the prediction of the energy.

2.3 Solar irradiance

Terms that related to the solar irradiance and the weather constrains that effect the solar irradiance value.

2.3.1 Irradiance

The design of a photovoltaic system relies on solar radiation at a particular site. Irradiance is the measure of the power density of sunlight or the total power from a radiant source falling on an area unit. Irradiance measured by unit W/m^2. The solar constant for Earth is the irradiance receives by Earth from the sun at the top of the atmosphere [11]:

$$S = E/(4\pi R^2) = 1370\ W/m^2 \tag{2.1}$$

Where :

E= Sun total power = $3.9 x 10^{26}$W
R= average earth/sun distance = $1.5 x 10^{11}$m

Whilst the irradiation is the measure of energy density of sunlight and is measured in kWh/m^2. Irradiation is the integral of irradiance since energy is integrated over time. In Figure 2.4, shows the solar radiate from the sun to the earth surface.

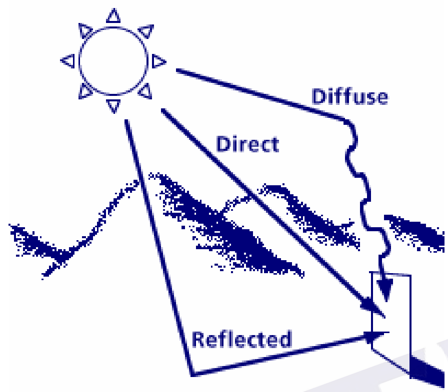

Figure 2.4: Way of solar radiate in the atmosphere

2.3.2 Constrain of weather conditions

The total irradiance of typical solar spectrum on the earth surface on a clear day is 1 kW/m^2. However, the availability of the irradiance usually considerably less than 1 kW/m^2 due to the rotation of the earth and due to the weather condition. On the sunny day, the irradiance are more higher than the rainy day.

Sunny is also known as sunshine. The condition when the direct solar radiation is not blocked by clouds, which is the combination of the bright light and radiant heat. The term 'sunshine duration' has been used to indicate the cumulative time during which an area receives direct irradiance from the Sun of at least 120 watts per square meter by World Meteorological Organization [12].

Cloudy is the condition that happens when sun is blocked by the clouds or reflects off of other objects, it is experienced as diffused light. In the rainy day the amount of solar radiation available during arainy day is drastically reduced compared to the sunny day.

2.4 The uses of Graphical User Interface (GUI)

The GUI is an illustrative platform and the co-ordinator between the data that user have uploaded and the simulation. The GUI also able to start the simulation properly and deliver the result needed. The GUI was created with Matlab, which is the user friendly interface that gives simplification for the program.

GUI is used in Matlab to perform the task simply by hiding unnecessary clutters and for the pictorial representation of the program [13]. GUI uses graphic and text input to make familiar environment for the user to execute the program. Various components used for the design of the GUI like push button, edit text, static text and axes. The description of the component use is explained in Table 2.1.

Table 2.1: GUI basic component

NO	COMPONENT	DESCRIPTION
1	Push Button	Created by uicontrolcallback. It triggers a call back when clicked by mouse
2	Edit Text	Created by uicontrolcallback. It used to display a string and allow the user to modify the information. It triggers a call back function when the user click the enter key
3	Static Text	Created by uicontrolcallback. It is used to display a string but does not allow the user to modify the information
4	Axes	Used to display the data

There are two basic tasks in process to implement a GUI. The two processes are:

(i) Laying out a GUI where Matlab implement GUIs as figure windows containing various styles of uicontrol (User Interface) object

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